Weed Technology. 2005. Volume 19:47–54

Effects of Application Rate, Timing, and Formulation of Glyphosate and Triclopyr on Control of Chinese Privet (*Ligustrum sinense*)[1]

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Abstract: Chinese privet is a nonnative shrub that has invaded mesic forests throughout the southeastern United States during the past century. Foliar sprays of glyphosate and triclopyr were tested in three factorial experiments that included wide ranges of application rate, timing, and formulation to refine methods for controlling Chinese privet. For spring (April) and fall (October and December) applications, percentage control of privet cover averaged 93 to 100% and 49 to 70% for glyphosate and triclopyr treatments, respectively, whereas for summer (June and August) applications, control averaged 67 to 69% and 14 to 26%, respectively (study 1). However, privet control was not influenced by variation in herbicide rates of 1.7, 3.4, 5.0, or 6.7 kg ae/ha compared with each of the five application timings. No differences were found in August comparisons of liquid vs. dry glyphosate products or water-soluble vs. oil-soluble triclopyr products for each of the four rates (study 2). In a comparison of low rates of glyphosate applied in August with or without trenching of plot perimeters to isolate privet clumps (study 3), control increased from 12 to 65% as rate increased from 0 to 0.8 kg ae/ha, suggesting that rate responses may occur at lower values than those tested in studies 1 and 2. Isolation of privet clumps by trenching did not have a statistically detectable effect on privet susceptibility to glyphosate. Low rates of glyphosate (1.7 kg ae/ha or possibly lower) will provide effective control of privet when applied in the spring or fall.

Nomenclature: Glyphosate; triclopyr; Chinese privet, *Ligustrum sinense* Lour.

Additional index words: Bottomland hardwoods, crown cover, invasive weeds, response surface analysis.

INTRODUCTION

Chinese privet is a rapidly encroaching plant that continues to invade disturbed sites, fencerows, and bottomland and upland forests in the Southeast (Dirr 1998; Haragan 1996; Miller 2003). This shade-tolerant, perennial shrub or small tree grows to a height of 9 m and has multiple stems (Miller 2003). Its foliage is evergreen to semievergreen, becoming deciduous in cold climates (Dirr 1998). Once liberated from their fleshy fruit, privet seeds will germinate promptly without cold stratification (Burrows and Kohen 1986; Young and Young 1992). The spread of its seeds by birds and other animals and abundant production of root sprouts enable the species to invade new areas and form dense thickets (Dirr 1998; Miller and Miller 1999). Because of the species' shade tolerance and abundant regeneration, privet is able to spread and thrive under dense forest canopies. As an additional layer of understory vegetation, privet may be an important factor limiting hardwood regeneration, wildlife habitat, biodiversity, and recreational activities.

Introduced from China in 1852 as a woody ornamental, Chinese privet has escaped and now dominates understories of mesic forests throughout the southeastern United States (Haragan 1996) and is moving into New England and the Midwest (USDA-NRCS 2003a). During the period of 1950 to 1980, Chinese privet distribution expanded at an exponential rate, and today it is present in over 40% of southeastern U.S. counties (USDA-NRCS 2003b). In a survey conducted by the USDA Forest Service, the Forest Inventory and Analysis Program estimated that *Ligustrum* spp. occupied approximately 5% of forestland area along the eastern seaboard from Virginia to Florida (Rudis and Jacobs 2002). Chinese privet is ranked among the top 10 exotic pest plants of Georgia (Georgia Exotic Pest Plant Council 2003) and Mississippi (Matlack 2002).

Herbicides are an important tool for controlling *Ligustrum* spp., although comprehensive comparisons of application rate and timing are not available in the pub-

[1] Received for publication September 23, 2003, and in revised form May 18, 2004.

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lished literature. In primary screening work, Miller (1998) observed 89 to 90% control of Chinese privet after 1 yr with high rates of glyphosate, imazapyr, or metsulfuron applied as foliar sprays in August, whereas control averaged only 60% after triclopyr. James and Mortimer (1984) successfully controlled privet with cut-stump applications of picloram plus 2,4-D or picloram plus triclopyr and with foliage applications of metsulfuron (spring or autumn) or glyphosate (spring only). Similarly, Little (1982) achieved control of 97% of privet plants by cut-stump application of picloram plus 2,4-D. Mowatt (1981) found consistently high levels of control when privet was injected with triclopyr or hexazinone but variable control when injected with glyphosate or dicamba.

Of the herbicides tested, glyphosate and triclopyr have no soil activity at registered rates (WSSA 1994) and pose little risk to associated vegetation when applied to privet as a directed foliar application. Other herbicides, such as picloram, imazapyr, and metsulfuron, have soil-activated phytotoxic effects on many hardwood tree species and therefore have restrictions when used for privet control in bottomland forests. To identify optimum application rates and timings of herbicides for a given target species, controlled studies are needed in which these factors are varied systematically and plant responses are quantified with objective measurements (Borders and Shiver 1989; Knowe et al. 1995). Therefore, the objective of this research was to compare control of Chinese privet abundance and height 2 yr after various application rates, timings, and formulations of glyphosate and triclopyr. Because a herbicide dose applied to privet in a small plot might be subject to excessive dilution within the creeping root system, we conducted a separate study in which privet control after low rates of glyphosate was compared in the presence vs. absence of trenching to sever the root system from nearby plants.

MATERIALS AND METHODS

Study Site and Treatments. The research was conducted in the understory of a 1.2-ha bottomland hardwood stand located at the confluence of McNutts and Barber creeks in Oconee County near Athens, GA (lat 33°57′N, long 83°19′W). Soils are gravelly sandy loams of the Madison series (fine, kaolinitic, thermic Typic Kanhapludults) and gravelly loams of the Louisa series (loamy, micaceous, thermic, shallow Ruptic-Ultic Dystrudepts) (USDA-NRCS 2003c). The upper canopy of the forest included, in decreasing order of abundance, river birch (*Betula nigra* L.), green ash (*Fraxinus pennsylvanica* Marsh.), boxelder (*Acer negundo* L.), red maple (*Acer rubrum* L.), yellow-poplar (*Liriodendron tulipifera* L.), American hornbeam (*Carpinus caroliniana* Walt.), water oak (*Quercus nigra* L.), and sweetgum (*Liquidambar styraciflua* L.). In spring 1999, a dense stand of privet, 2 to 4 m in height, was cut to a 15-cm height by the Georgia Department of Transportation in preparation for a stump application of the triethylamine salt of triclopyr in water. However, the herbicide treatment was delayed for several weeks, and no signs of plant injury were visually detectable at study initiation (spring 2000). Triclopyr entry into the privet stumps probably was prevented by blockage of the xylem vessels, which can occur within 2 h after cutting the stem of a woody plant (Newton and Knight 1981).

In April 2000, the study site was dominated by a uniform stand of 1-yr-old privet sprouts about 1 m in height. A total of 218 plots, each 3 by 6 m in dimension, were located in a contiguous grid. Three studies were initiated to compare privet control subsequent to a variety of treatment specifications (Table 1). Study 1 compared four application rates (kg ae/ha) and five timings of glyphosate and triclopyr. Study 2 compared two formulations and four rates of glyphosate and triclopyr applied in August 2000. Studies 1 and 2 had randomized complete block designs with four replications of each treatment. Blocks ran parallel to McNutts Creek and were assigned according to distance from the creek because flooding can limit privet growth (Brown and Pezeshki 2000). Four of the plots (one per block) were randomly assigned as nontreated checks. Using the remaining plots, study 3 compared three application rates of glyphosate applied in August 2000 with or without trenching of plot perimeters to a depth of 50 cm with a Ditch Witch[3] to isolate privet clumps. Study 3 had a completely randomized design with three replications of each treatment because plot locations did not conform to the blocked designs of studies 1 and 2. Plots for the three studies were randomly interspersed. To evaluate control resulting from a nonherbicide treatment, four plots were designated for manual uprooting of privet in June (one plot per block). The time required to manually uproot the privet on a given plot was recorded (min/m^2). Seedlings and small clumps were uprooted by hand, whereas larger clumps were uprooted with a winch puller.[4]

Herbicide treatments for study 1 were applied on the following dates in 2000: April 20, June 19, August 23,

[3] Model 1230, walk-along trencher, Ditch Witch, 4501 East Second, Edmond, OK 73034-7500.

[4] Model 144, winch puller, Ben Meadows Co., P.O. Box 5277, Janesville, WI 53547-5277.

Table 1. Experimental design features of studies 1, 2, and 3 for control of Chinese privet. Four additional plots (one per block) were designated as nontreated checks, and four additional plots (one per block) were designated for manual uprooting of privet in June.

		Herbicide	
Study	Factors (levels) tested	Common name	Commercial name[a]
1[b]	Herbicides (2), application rates (4), and application timings (5)[c]	Glyphosate	Accord®SP
		Triclopyr	Garlon®3A
2	Herbicides (2), formulations (2), and application rates (4)	Glyphosate	Accord®SP
			Roundup®Pro Dry
		Triclopyr	Garlon®3A
			Garlon®4[d]
3	Rates (3), trenching levels (2)	Glyphosate	Accord®SP

[a] Accord®SP (isopropylamine salt of glyphosate), Garlon®3A (triethylamine salt of triclopyr), and Garlon®4 (butoxyethyl ester of triclopyr) are products of Dow AgroSciences LLC, Indianapolis, IN, and Roundup®Pro Dry (ammonium salt of glyphosate) is a product of the Monsanto Company, St. Louis, MO.

[b] Study 1 had a total of 160 plots (four replications of 40 treatments), study 2 had a total of 64 plots (four replications of 16 treatments) of which 32 were shared from study 1 (those for the August timing of the Accord®SP and Garlon®3A treatments), and study 3 had a total of 18 plots (three replications of six treatments).

[c] Herbicide application rates were 1.7, 3.4, 5.0, and 6.7 kg ae/ha for studies 1 and 2, and 0, 0.4, and 0.8 kg ae/ha for study 3. Application timings were April, June, August, October, and December 2000 for study 1 and August 2000 for studies 2 and 3.

[d] Improved JLB®Oil Plus (Brewer International, P.O. Box 690037 Vero Beach, FL 32969) was used as a spray carrier for Garlon®4, whereas water was used as the spray carrier for all other herbicides.

October 16, and December 7. Rainfall in the month before each treatment was, respectively, 58, 21, 45, 117, and 111% of the long-term average. Treatments for studies 2 and 3 occurred on August 23, 2000. Air temperatures during the December treatment ranged from 11 to 14 C; temperatures during all other application timings were well above freezing. All treatments were applied with a CO_2-pressurized backpack sprayer[5] with a four-nozzle boom that created a uniform 1.8-m band of spray. The sprayer was calibrated with 8002VS flat-fan spray nozzles[6] with a pressure of 200 kPa for an output rate of 187 L/ha to ensure complete coverage of the privet canopy within a 1.8-m band centered across the 6-m length of each plot (approximately 60-cm bands on either side remained nontreated as plot buffers). Boom height was kept about 50 cm above the top of the privet canopy for each application timing.

Vegetation Measurements. Just before each application timing, the following variables were measured on privet rooted within each of three square, 1-m^2 subplots centered at pin flags placed permanently 1, 3, and 5 m along the centerline of the 6-m dimension of each plot: cover (visually estimated percentage of area occupied by plant crowns), stem density (stems/m^2), and height (cm, tallest stem per subplot). All vegetation measurements were repeated in October 2002, an average of two growing seasons after the various application timings.

To provide an index of overstory forest density, total stem cross-sectional area of trees (stand basal area; m^2/ha) was measured as follows. At each of 26 systematically located points within the study area, stem diameter (cm) at 1.37 m height (diameter breast height, dbh) was measured on each tree (dbh > 2.5 cm) whose center was rooted within 6 m of a given point (sample area = 0.01 ha). The total cross-sectional area (m^2) of stems measured around each point was divided by sample area to equal stand basal area. Each treatment plot was assigned the value of stand basal area from the closest point.

Statistical Analysis. Control (%) of privet cover, density, and height was calculated by subtracting posttreatment (2002) values for each subplot from their respective pretreatment (2000) values, expressing this difference as a percentage of the mean posttreatment value for the nontreated check plots (26.8%, 20.8 stems/m^2, and 177 cm for cover, density, and height, respectively), and then averaging the percentages by plot. Note that this numerical expression of control could exceed 100% for individual plots and that negative values for control indicated that privet abundance or height increased during the study.

Data from each study were subjected to stepwise linear regression (SAS 1999a) to fit response surface models (Petersen 1985) with the minimum number of variables needed to account for significant ($\alpha = 0.05$) effects of the various experimental factors (see model equations below). This analytical approach is appropriate for herbicide trials that test quantitative factors because it enables identification of optimum application rates and timings (Borders and Shiver 1989). Stand basal area of overstory trees and the time interval between pre- and posttreatment measurements (days) were tested as poten-

[5] Model GS, CO_2 backpack sprayer with four-nozzle spray boom, R&D Sprayers Inc., 419 Highway 104, Opelousas, LA 70570.

[6] Nozzle 8002VS, Visiflo flat spray tip, Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60189-7900.

Table 2. Average pre- and posttreatment values and percentage control values of Chinese privet cover, density, and height (standard errors in parentheses) for various application timings of glyphosate and triclopyr (study 1). Averages have been computed across all application rates. Figure 1 provides a graphical representation of privet control vs. application timing.

Variable	Application timing	Glyphosate			Triclopyr		
		Pretreatment	Posttreatment	Control (%)[a]	Pretreatment	Posttreatment	Control (%)
Cover (%)	April	26.8 (0.5)	1.8 (2.7)	93.2 (10.1)	27.9 (3.3)	14.9 (1.7)	49.4 (11.4)
	June	22.6 (1.2)	4.0 (2.3)	69.3 (10.8)	27.8 (3.3)	20.7 (2.6)	26.4 (15.0)
	August	20.7 (1.1)	2.8 (1.3)	66.9 (6.4)	19.9 (2.8)	16.1 (2.2)	14.2 (9.9)
	October	26.9 (0.1)	0.3 (3.2)	99.4 (11.9)	29.8 (2.9)	13.3 (2.3)	61.6 (12.1)
	December	28.0 (0.1)	0.3 (3.0)	103.5 (11.0)	23.4 (1.2)	4.5 (1.7)	70.3 (6.2)
Density (stems/m^2)	April	22.9 (0.5)	1.9 (2.3)	100.9 (10.8)	27.0 (2.5)	13.4 (1.9)	65.4 (10.5)
	June	16.8 (1.3)	4.5 (1.6)	59.2 (8.6)	21.2 (2.3)	14.5 (3.2)	32.4 (15.7)
	August	21.1 (1.1)	3.6 (1.3)	83.8 (7.2)	16.5 (1.6)	11.3 (1.4)	24.8 (8.8)
	October	25.6 (0.2)	0.6 (4.3)	119.9 (20.9)	28.4 (2.2)	11.9 (2.9)	79.0 (11.3)
	December	21.3 (0.2)	0.5 (2.4)	100.0 (11.4)	22.4 (1.4)	5.5 (3.4)	81.3 (12.6)
Height (cm)	April	111.8 (7.2)	25.4 (7.8)	48.7 (5.8)	111.3 (16.1)	100.1 (7.0)	6.3 (7.5)
	June	116.2 (8.7)	43.3 (5.0)	41.1 (6.7)	113.6 (12.1)	99.1 (7.4)	8.2 (6.3)
	August	134.1 (6.9)	32.0 (7.9)	57.6 (6.3)	126.5 (15.1)	109.6 (8.2)	9.5 (7.5)
	October	132.0 (2.6)	8.3 (9.0)	69.8 (5.3)	136.2 (12.5)	73.3 (10.7)	35.5 (8.9)
	December	138.5 (4.4)	9.6 (10.0)	72.7 (5.7)	121.9 (9.9)	45.8 (8.8)	42.9 (5.8)

[a] Privet control was calculated by subtracting posttreatment values from respective pretreatment values and expressing this difference as a percentage of the mean posttreatment value for the nontreated check plots (26.8%, 20.8 stems/m^2, and 177 cm for cover, density, and height, respectively).

tial covariates in the response surface models. Proc RSREG was used to test model lack of fit and the overall significance of the application rate, timing, and formulation variables (SAS 1999b). Scatter plots of the residuals from each regression against predicted values indicated that the residual variances were relatively homogenous and that transformations of the dependent variables were not necessary. Other expressions of woody plant response to herbicide treatments (absolute abundance and height and the proportionate change estimators of Knowe et al. [1990]) were tested for privet and rejected because they did not provide homogeneous distributions of the residuals. The following is the full-regression model tested for study 1:

$$Y = B_0 + B_1(Y_i) + B_2(BA) + B_3(t) + B_4(r_2) + B_5(r_3) + B_6(r_4) + B_7(H) + B_8(A) + B_9(M) + B_{10}(A^2) + B_{11}(M^2) + B_{12}(H)(A) + B_{13}(H)(M) + B_{14}(A)(M) \quad [1]$$

where Y is the percentage control of privet cover, density, or height; B_0 to B_{14} are regression coefficients to be estimated; Y_i is pretreatment cover, density, or height; BA is overstory stand basal area (m^2/ha); t is the time interval (days) between pre- and posttreatment measurements; r_2 to r_4 are indicator variables specified to represent blocks 2, 3, and 4, respectively (Sokal and Rohlf 1981); H is an indicator variable specified to represent herbicide ($H = 1$ if glyphosate, and $H = 0$ if triclopyr); A is herbicide rate (kg ae/ha); and M is application timing specified as a numerical designation of month (i.e., 4, 6, 8, 10, or 12).

The following is the full regression model tested for study 2:

$$Y = C_0 + C_1(Y_i) + C_2(BA) + C_3(r_2) + C_4(r_3) + C_5(r_4) + C_6(H) + C_7(F) + C_8(A) + C_9(A^2) + C_{10}(H)(F) + C_{11}(H)(A) + C_{12}(F)(A) \quad [2]$$

where Y, Y_i, BA, r_2 to r_4, H, and A are as described above for model [1]; C_0 to C_{12} are regression coefficients to be estimated; and F is an indicator variable specified to represent the alternative formulation for either glyphosate ($F = 1$ if glypohosate dry formulation, and $F = 0$ if glyphosate liquid formulation) or triclopyr ($F = 1$ if in oil, and $F = 0$ if in water).

The following is the full regression model tested for study 3:

$$Y = D_0 + D_1(Y_i) + D_2(BA) + D_3(A) + D_4(T) + D_5(A)(T) + D_6(A^2) \quad [3]$$

where Y, Y_i, BA, and A are as described above for model [1]; D_0 to D_6 are regression coefficients to be estimated; and T is an indicator variable specified to represent presence ($T = 1$) or absence ($T = 0$) of trenching of plot perimeters to isolate privet clumps.

RESULTS AND DISCUSSION

General Information. Pretreatment cover, density, and height of Chinese privet averaged 25%, 22 stems/m^2, and

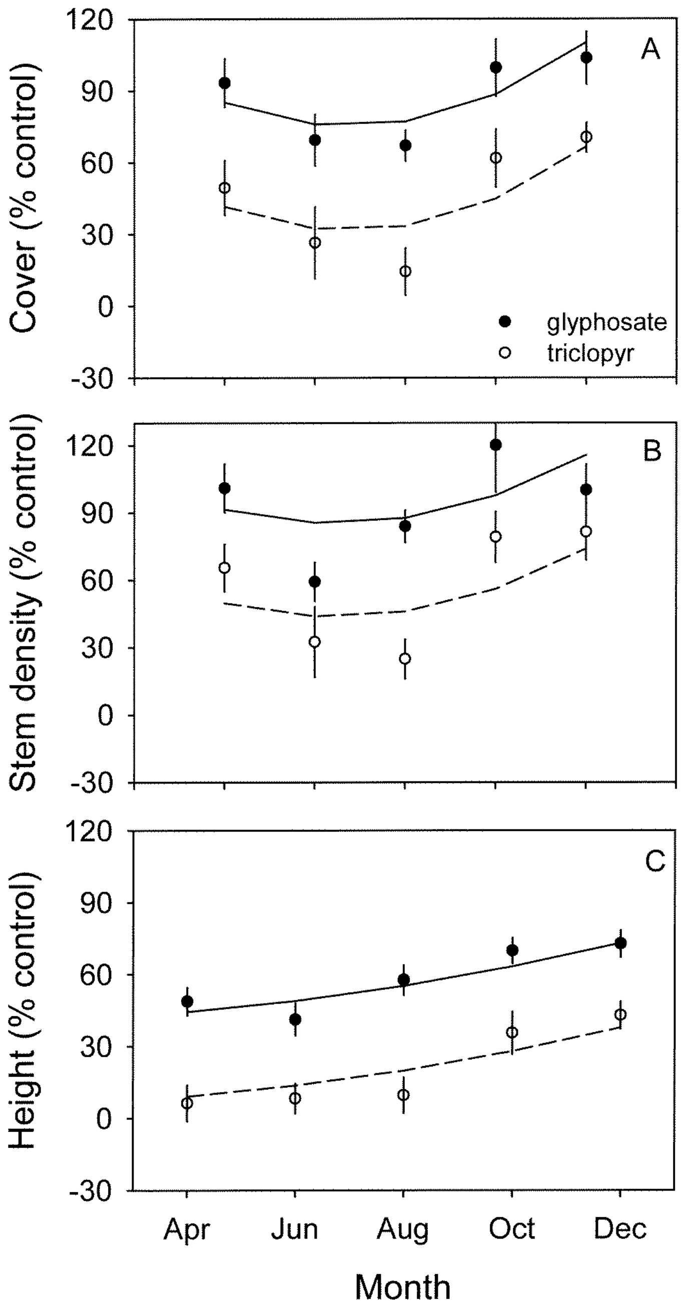

Figure 1. Average values (± standard error) and response surface predictions (fitted curves) for 2-yr (2000 to 2002) control of Chinese privet (A) cover, (B) density, and (C) height as influenced by application timing of glyphosate and triclopyr (study 1). Numerical values are provided in Table 2. Response models (fitted curves) have been adjusted for mean values of pretreatment cover, density, or height and stand basal area of overstory trees.

124 cm, respectively, across all application rates and timings for study 1. Lack of fit for each of the response surface models was not significant. In each model, pretreatment abundance (i.e., cover or density) or height was a significant variable; however, indicator variables for blocks were not significant. The time interval between pre- and posttreatment measurements also was not a significant variable in the regression models for study 1. Stand basal area of overstory trees was a significant variable in the models for studies 1 and 2. For example, the average overstory basal area of 6.5 m^2/ha was associated with 4% of additional control of privet cover in study 1. In general, decreases in light intensity and increases in humidity have been associated with increased glyphosate absorption for a variety of herbaceous species (Hess 1987). A similar response may have occurred for privet growing in the shade and elevated humidity of the forest understory.

Study 1: Comparison of Herbicide Application Rates and Timings. Herbicide rate did not have a statistically detectable effect on control of Chinese privet. Control of privet cover (averaged across rates) after spring (April) and fall (October and December) applications averaged 93 to 100% and 49 to 70% for glyphosate and triclopyr, respectively (Table 2). However, control was substantially less after summer (June and August) applications (averages of 67 to 69% and 14 to 26% control for glyphosate and triclopyr, respectively). Droughty conditions that preceded the June and August timings may have limited herbicide efficacy; however, drought is common during this period. Severe moisture stress limited absorption and translocation of glyphosate in several common herbaceous (Lauridson et al. 1983; Moosavi-Nia and Dore 1979) and woody species (D'Anieri et al. 1990). Severe moisture stress also limited translocation of triclopyr to stems and roots of water oak and southern red oak (*Quercus falcata* Michx.) (Seiler et al. 1993) and red maple (Bollig et al. 1995). In addition, late spring and summer are the periods when shoot growth (Stromayer et al. 1998) and flowering (Miller 2003) are most active for Chinese privet and translocation of photosynthates is likely to be primarily upward and therefore less able to transport herbicides to the roots.

The relationships for control of privet cover and density to application timing had similar curvilinear shapes (Figures 1A and 1B). Regression models explained 66 to 75% of the total variation in these variables, and they included the quadratic term for application timing listed in model [1], M^2 (Table 3). The regression coefficient for the H parameter in model [1] indicated that control of cover and density was 42 to 44 percentage points greater after glyphosate than after triclopyr. The parallel nature of the relationships for glyphosate and triclopyr suggests that similar factors of plant physiology (e.g., plant water stress) were operating to limit efficacy of the two herbicides during summer.

Japanese privet (*Ligustrum japonicum* Thunb.), a *Li-*

Table 3. Regression coefficients and fit statistics from study 1 response surface analyses for 2-yr (2000–2002) control of Chinese privet cover, density, and height after various application timings and rates of glyphosate and triclopyr. Coefficients in each model were significant at $P \leq 0.05$. Models are illustrated graphically in Figure 1.

Dependent variable	Independent variables[b]	Regression coefficients	Fit statistics[a] R^2	ΔR^2	$s_{y \cdot x}$	n
Cover (% control)	B_0	9.21	0.655	—	30.1	160
	Y_i	3.05		0.386		
	BA	0.686		0.020		
	H	43.6		0.189		
	M	−17.6		0.031		
	M^2	1.29		0.029		
Density (% control)	B_0	−6.27	0.754	—	28.1	160
	Y_i	3.94		0.564		
	BA	0.570		0.013		
	H	41.7		0.140		
	M	−12.9		0.023		
	M^2	0.994		0.014		
Height (% control)	B_0	−39.5	0.592	—	22.6	160
	Y_i	0.326		0.229		
	BA	0.711		0.029		
	H	35.3		0.252		
	M^2	0.223		0.082		

[a] R^2 is the coefficient of determination, ΔR^2 is the proportion of total variation in the dependent variable explained by a given independent variable, $s_{y \cdot x}$ is the standard error of estimate, and n is the sample size.

[b] B_0 is the regression intercept, Y_i is pretreatment cover (%), density (stems/m^2), or height (cm), BA is stand basal area of overstory trees (m^2/ha), H is an indicator variable for herbicide (H = 1 if glyphosate and H = 0 if triclopyr), and M is application timing (numerical designation of month).

gustrum species having greater stature and waxier leaves than Chinese privet, was most sensitive to glyphosate when laboratory applications were made at budbreak, when absorption and transport of the herbicide was greatest (Neal et al. 1985). In general, incomplete development or relative absence of the waxy cuticle on a leaf surface will enable greater absorption of water-soluble herbicides (Hess 1987). In this experiment, perhaps the less waxy leaves of Chinese privet, compared with Japanese privet, and the downward translocation of photosynthates resulted in greater glyphosate susceptibility in the fall as found for deciduous fruit trees (Putnam 1976; Weller and Skroch 1983).

The relationship between control of privet height and application timing (Figure 1C) was not as curvilinear as that observed for control of cover and density (Figures 1A and 1B). Instead, control of height increased in a relatively linear fashion as application timing varied from April to December. The response surface model explained 59% of the total variation in control of height, and it included a quadratic term for application timing (Table 3). The regression coefficient for the H parameter in model [1] indicated that control of height averaged 35 percentage points greater after glyphosate than after triclopyr.

Response to Manual Uprooting. Manual uprooting of Chinese privet in June resulted in 57, 56, and 38% control of cover, density, and height, respectively. These levels of privet control were similar to the average of those reported for the triclopyr treatments (Table 2). Privet regrowth originated primarily from root sprouts. The average time required for one person to conduct manual uprooting of privet was 14 min/m^2. Small seedlings were relatively easy to uproot by hand, whereas the larger clumps had to be uprooted with the leverage provided by a winch puller. Clearly, the size of privet plants and the depth of their rooting greatly affected the production rate of this treatment.

Study 2: Comparison of Herbicide Formulations and Rates. Control of cover, density, and height of Chinese privet did not differ significantly between the two formulations of glyphosate (liquid formulation vs. dry formulation) or triclopyr (water soluble vs. oil soluble) when applied in August (Figure 2). As found in study 1, rate did not have a significant influence on privet control in study 2. The regression coefficient for the H parameter in model [2] indicated that control of privet cover, density, and height averaged 41 to 51 percentage points greater after glyphosate than after triclopyr treatments. Because study 2 was conducted only in August, when droughty conditions may have limited herbicide uptake and translocation, this comparison of herbicide formulations cannot identify whether differences would exist for other application timings.

Study 3: Susceptibility of Isolated vs. Stand-Grown Privet to Glyphosate. Average control of privet cover

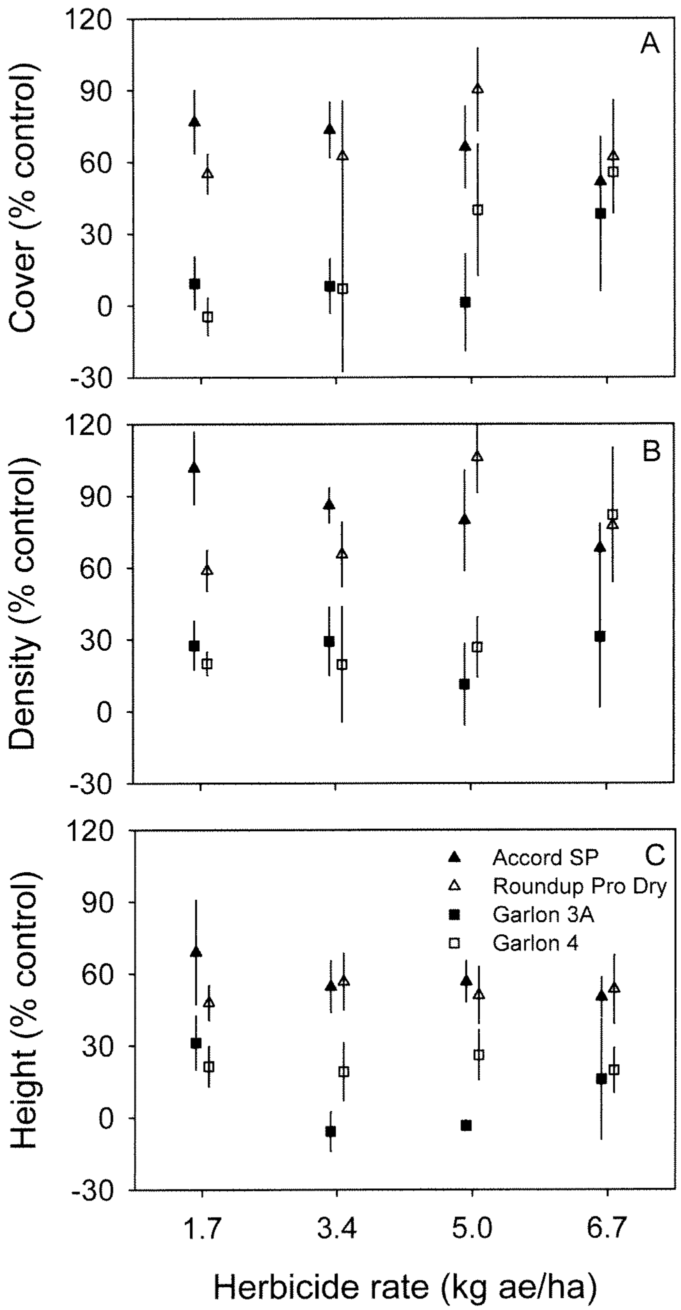

Figure 2. Average values (± standard error) for 2-yr (2000 to 2002) control of Chinese privet (A) cover, (B) density, and (C) height as influenced by application rate and formulation of glyphosate and triclopyr applied in August (study 2). Herbicide rate and formulation had no statistically detectable effects on privet control (P > 0.05).

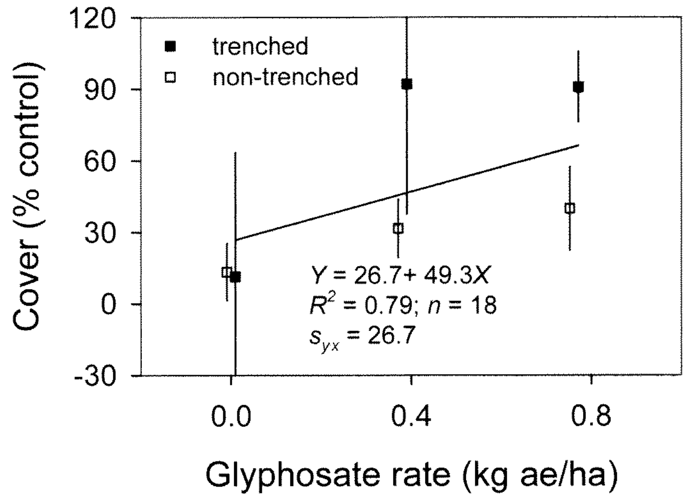

Figure 3. Average values (± standard error) for 2-yr (2000 to 2002) control of Chinese privet cover as influenced by glyphosate rate and presence vs. absence of trenching of plot perimeters to isolate privet clumps (study 3). Trenching did not have a statistically detectable effect on privet control (P > 0.05). The response model (fitted lines) has been adjusted for mean pretreatment cover.

increased from 12 to 65% as glyphosate rate increased from 0 to 0.8 kg ae/ha (Figure 3). Similar responses were observed for control of density and height (R^2 = 0.56 to 0.91; data not shown). Although control from glyphosate averaged much greater for isolated (trenched) (91%) than for stand-grown privet (36%), differences were not statistically significant because of high variability among plots. However, results from study 3 indicate that glyphosate rates less than 1.7 kg ae/ha provided a significant degree of privet control, and this may explain the observed absence of herbicide rate effects in studies 1 and 2. In study 3, privet was susceptible to glyphosate rates lower than those tested in studies 1 and 2, even in August when control was lowest. Therefore, each of the glyphosate rates tested in studies 1 and 2 probably exceeded the dose needed to provide the maximum control possible for a given application timing.[7]

ACKNOWLEDGMENTS

This research was funded by the Georgia Department of Transportation, Atlanta, GA. We are grateful to J. Gatch, M. Murphy, G. Ahuja, and D. Marshall for assistance with plot establishment, treatment application, and vegetation measurements. We are also thankful to L. Priestley for logistical support and to E. Cole, S. Knowe, and S. Zedaker for manuscript reviews. In addition, we thank Dow AgroSciences LLC and the Monsanto Com-

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pany for providing technical advice and donating herbicides.

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